INTRODUCTION

Amusement parks have a long tradition of hosting physics days. Students look forward to the field trip—after all, they get to go to an amusement park for the day—and it's educational. Teachers like the excitement that the event generates, while providing them with a situation in which to apply concepts of measurement, estimation, gravity, motions, forces, and systems. Students are engaged in the inquiry process to gather data firsthand and apply what they've learned to a real situation. The results may be more or less accurate, but the process is an authentic opportunity to conduct real science and apply math concepts in contexts outside of the classroom (Standard 9c, National Mathematics Content Standards by the National Council of Teachers of Mathematics (NCTM)). This type of an educationally rich experience, which meets state and national standards, increases the likelihood of school administrations approving the field trip. Organizing a field trip is an undertaking. The goal of this guide is to make the teachers' jobs simpler to facilitate and adequately prepare students for a successful learning experience at the amusement park.

Cedar Point's Magnum XL–200 has a lift hill that is over 200 feet tall. The coaster has no loops in its out-and-back course. The Magnum XL–200 is located at Cedar Point, Sandusky, Ohio.

What does amusement park physics have to do with NASA?

While many guides relating to amusement park physics exist, this guide is unique because it examines how the physics of motion applies to aeronautics and astronautics. Amusement parks are one of the best places to feel firsthand what astronauts experience while in space. For example, during launch, the thrust of the space shuttle's engines cause astronauts to experience forces up to three times Earth's gravity (3 g). Some roller coasters give riders up to 3.7 g. Likewise, weightless conditions experienced during astronaut training and on orbit can be felt on amusement park rides that plummet straight down or crest over hills. This guide contains a section that makes the NASA connection for specific amusement park rides.

How did this guide develop?

NASA Glenn Research Center in Cleveland, Ohio, has long supported Amusement Park Physics Days at Cedar Point, Geauga Lake, and now Six Flags. Scientists and engineers volunteer each year to visit schools and go to the parks to demonstrate and explain how NASA ties into amusement park physics, particularly with the two drop towers at Glenn Research Center. Teachers attending NASA educator workshops and the amusement parks expressed interest in developing a guide in partnership with the National Center for Microgravity Research (NCMR). In particular, educators from Emerson Middle School in Lakewood, Ohio, have partnered closely with NCMR. This guide has been developed over the past 4 years, creating activities, testing them at the park with over 1500 students, and revising the materials according to successes and failures. As a result, the draft of the guide reached a sufficient degree of quality for a formal pilot program with educators throughout Ohio. Now with completion of the pilot program the guide has been revised and is available nationally online through NASA Spacelink (spacelink.nasa.gov) and through the NASA Educator Resource Network (see page 146).

For what grades is this guide appropriate?
Many amusement park physics guides are geared toward high school level science and mathematics classes. This guide does not require knowledge of trigonometry or calculus. The intended audience is primarily students in seventh through ninth grades. Since high school level mathematics is not used and the measurement tools are fairly low-end technologies, and not terribly accurate, the emphasis is less on getting the "correct" answer and more about making reasonable estimations and the thinking process. Note, upper elementary school teachers have found this guide to be appropriate for classes for gifted and talented students. However, this age group may lack the necessary motor skills to operate stop watches and take consistent altitude tracker readings.

How is this amusement park guide different from other guides?
Most amusement park physics guides focus primarily on problem sets and are geared towards using trigonometry and calculus. This is a middle school guide that makes the NASA connection to the rides. All of the activities are centered on preparing students to complete worksheets for specific rides. The science and mathematics teachers can prepare students to use a single method or several methods for gathering the data. In addition, the guide is geared to help plan and run a successful field trip. After having many amusement park field trips, in all types of weather, with all types of students, and involving teachers of many different subjects, we have learned a lot about what works and what does not. Included in this guide you will find what the teachers found to be most essential in preparing and running this field trip.

How to use this guide
The sections found in the guide include

- ***Background Information***—covers amusement park physics, gravity, forces and motion, and microgravity. This information is for the teacher, but may also be given out to the students.
- ***Basic Skills***—discusses skills needed to do classroom activities and ride worksheets at the amusement park. Skills involve using a stopwatch, walking baselines, taking altimeter readings, calculating heights and speeds, and making and using accelerometers.
- ***Classroom Activities***—contains 2 weeks worth of activities designed to provide students with skills needed to complete ride worksheets at the park.
- ***NASA Connections***—makes the NASA tie-in with each amusement park ride.
- ***Ride Worksheets***—can be used as a workbook for specific rides at the amusement park.
- ***Answer Key***—gives approximate answers for each of the classroom activities and ride worksheets.
- ***Tests***—provides a pretest and posttest to show students and teachers how much they have learned from this unit on motion and forces.
- ***Forms and Extras***—includes tips and forms to help get the trip organized and methods for facilitating a successful experience at the park.
- ***Resources***—covers vocabulary, formula list, Web sites, and other useful NASA resources for educators.

To get a sense of the scope of the content, read through the Ride Worksheets and Answer Key sections first. Remember that for middle school students, the emphasis is less on getting a “correct” answer than using the problem-solving process. The measurement tools are not highly accurate, but if used correctly can provide comparative values. The basic skills and classroom activities prepare students to successfully complete the ride worksheets at the park. If you or your students need more science and math information related to forces and motion, consult the background information. The Background Information section can be used as a student handout or as a teacher reference.

Plan on spending at least 2 weeks prior to the spring field trip working on the classroom activities. Ideally, the science and mathematics teachers should work closely together to coordinate teaching basic skills. One option is to begin the unit with the pretest to see what students know about motion and forces. Then give the posttest after the field trip to see what the students have learned. The English teacher can assist in the preparation process too by reinforcing or even introducing the NASA Connections section with a worksheet activity.

When it comes to organizing the field trip, read through the planning schedule that follows. We recommend generating interest and support from school administrators, parents, students, and fellow teachers early in the semester in which you plan to implement this guide. Some schools have had success with high school physics students assisting student teams at the amusement park. Many schools have fundraisers to subsidize paying for school buses, purchasing measurement equipment, and even partially or completely paying for the students’ tickets. The forms and extras section includes a letter of permission for parents, ways to keep track of supply bags, teams of students, and attendance lists for riding the buses. From past experience, teachers and parents that volunteer to be of assistance at the amusement park prefer to just learn the worksheet for their particular assigned ride station. If possible, attend an amusement park physics workshop for educators at NASA Glenn Research Center. Visit *www.ncmr.org/education/k12/workshops.html* for information on future workshops.

The Dungeon Drop, located at Six Flags AstroWorld in Houston, Texas, stands 230 feet high. The feeling of weightlessness the riders experience is enhanced by extending their arms and legs.